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OBSERVATIONS OF SOME EUROPEAN WATER PURIFICATION AND SEWAGE DISPOSAL PLANTS*

By Edward Bartow

During a trip to Europe in the summer of 1914, some of the European practices in water purification, in sewage disposal, and in laboratory control were observed. No special outline was made for the trip, beyond a plan to visit certain prominent men who would know the latest developments along the lines to be investigated. No definite schedule was planned, so that places off of a regular line might be visited, in accordance with the instructions of the men consulted. After August first, owing to the war, nearly three weeks of a gradually developed schedule had to be abandoned. It was impossible to carry out plans to visit Strasburg to see the fish ponds used for sewage disposal; Lunéville to see the water purification by means of ultra-violet rays; Frankfort, Cologne, the Essen district and Ghent, to see special methods of sewage disposal. No attempt was made to see any plants in the neighborhood of Paris. In London all permits to visit the reservoirs of the water department had been withdrawn, and armed guards watched the reservoirs day and night.

Many of the European water purification plants and sewage disposal works have been described by others, an attempt will be made, therefore, to describe only what seemed to be unique. Owing to the fact that water purification and sewage disposal are so closely related, a chronological order will be followed in the observations.

Hamburg was the first city visited. The water supply of Hamburg is taken partly from the Elbe River and partly from wells. The water works are located on the river above the city, but, the Elbe being a tidal water, at times the sewage polluted waters of the river reach the intake. It is customary only during the ebb tide to pump the water into the large settling basins. Altona which adjoins Hamburg down the river, obtains its water supply from a point below the sewers of both cities. Reversing the practice of Hamburg, Altona pumps water into its purification works only during the flood tide. The Elbe River through Hamburg and Altona is therefore like a large tank disposing of the sewage which is passed into it. The only treatment Hamburg sewage receives is screening through revolving screens composed of aluminum bars about one foot long, placed about one centimeter (a little less than one-half inch) apart. The flow of the water in the river averages 1200 cubic meters per second. The dry weather flow of the sewage is 3 to 4 cubic meters per second, and the wet weather flow 20 cubic meters per second, so that there is ample dilution to prevent any nuisance, and to allow the water to be satisfactorily purified for drinking purposes. At the water purification plant alum is used as a coagulant prior to sedimentation. It is thought that Hamburg has the only purification plant on the continent where a coagulant is allowed. The water, after passing through large sedimentation basins, is filtered through slow sand filters (Fig. 1). These filters are uncovered, and in winter are covered with ice. Owing to the fact that there is a prejudice against the use of water taken from the river, the water department is endeavoring to develop a ground water supply. A number of wells have been sunk, and considerable water obtained, but the Hamburg authorities are handicapped by the fact that there is not sufficient area in Hamburg for proper development of ground waters. Hamburg is unable to extend its well system into Prussia, and, for the disposal of its sewage, has purchased from Prussia an island in the lower Elbe. The situation is similar to one in this country, where New York City cannot go outside of New York State to Connecticut or New Jersey for its water supply. The ground water obtained by Hamburg contains so much iron that iron removal plants have been constructed.

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* Paper read before a special meeting of the Illinois Water Supply Association (Illinois Section of the American Water Works Association), November 11, 1914.

While the sewage from the city of Hamburg itself is easily disposed of by the dilution method, several of the smaller cities under the direction of the Hamburg authorities are located so far from the river that another means of purification is necessary. At Bergedorf, a city of 15,000 inhabitants, located about ten miles from Hamburg, no water whatever is available for sewage dilution. Purification is accomplished by Imhoff tanks and sprinkling filters, followed by fish ponds.[1] This is a modification of a system of purification introduced at Strasburg, under the direction of Professor Hofer of Munich,[2] where satisfactory results with a dilution of two or three parts of pure water are claimed. At Bergedorf with no dilution it has been possible to satisfactorily purify the effluent from the sprinkling filters. The purification is accomplished with the assistance of water plants (Fig. 2) which apparently remove the toxic properties of the sewage, and make the water suitable for fish culture. Fish placed in the ponds in the spring grow rapidly during the summer. The flesh is good, especially if the fish are transferred to pure water for one or two weeks before they are eaten.

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[1] K. Allen, *Municipal Engineering*, 47, 197–201.

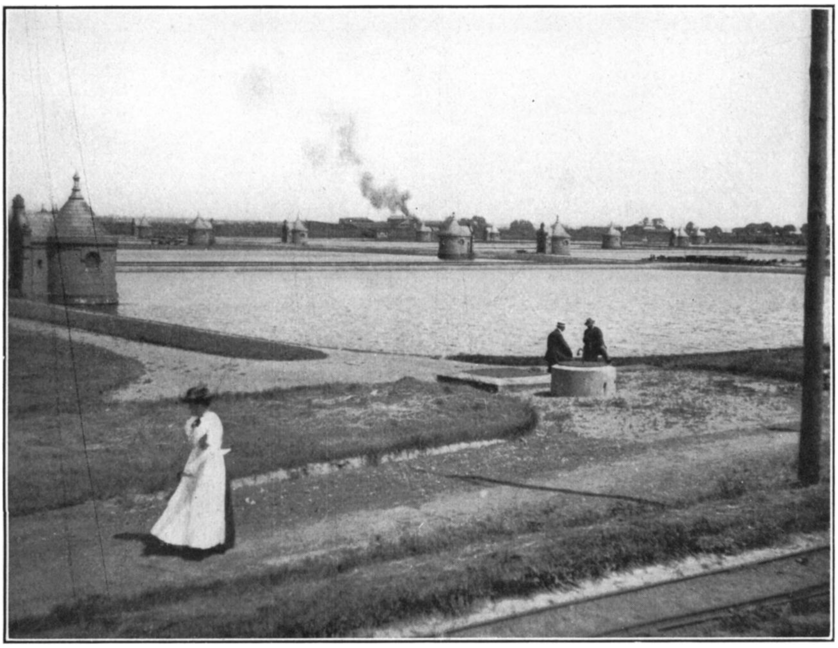

FIG. 1. SLOW SAND FILTERS, HAMBURG, GERMANY

At Berlin the Laboratory for Water Hygiene, located at Berlin-Dahlem, was especially interesting. In 1901 the Royal Research and Testing Station for Water and Sewage Purification was established. At the end of twelve years the organization had grown so much that a new building costing $125,000 was constructed (Fig. 3). The name of the organization has been changed to "Landesanstalt für Wasserhygiene."[3]

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[2] Hofer, *Fischerei Zeitung*, 16, 148.

This laboratory has control of the water supplies and sewage disposal plants in the province of Prussia. It also does commercial work for other German provinces and for foreign countries. Work of investigation is often done in coöperation with officers in cities and villages, and joint articles are frequently published by members of the staff and the city officials. At the present time the staff numbers forty workers. The scientific publications from the laboratory are of great value. The new building contains library space which will accommodate 30,000 volumes. In July, 1914, one hundred and one journals were regularly received. An attempt was being made to have available for the use of the laboratory staff all literature in all languages, concerning water. In April and October instruction is given to water works men in methods of water supply and sewage disposal. Regular lectures are given, and the men are

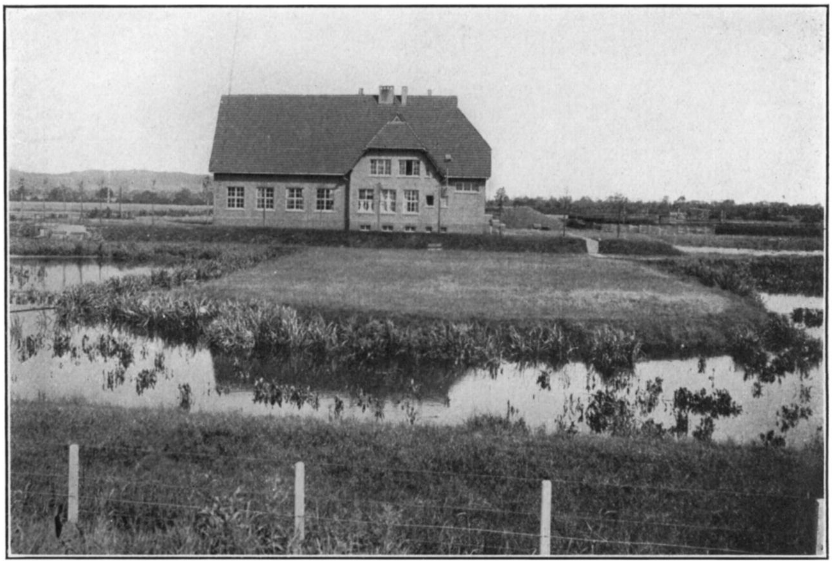

FIG. 2. FISH POND AND LABORATORY OF THE BERGEDORF, GERMANY, SEWAGE DISPOSAL WORKS. PHOTOGRAPH BY DR. KEIM

taken on trips to interesting plants in the neighborhood of Berlin. Professor Dr. Thum of the laboratory very kindly outlined several trips which would be most advantageous to take in the limited time which could be devoted to this section.

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[3] Mitteilungen aus der Königlichen Landesanstalt für Wasserhygiene, 17.

The water supply of Berlin is obtained partly from lakes and partly from wells. In Berlin, as in Hamburg, there is a prejudice against water from surface sources, and the authorities are endeavoring to replace the lake supplies by ground water supplies. At Mugglesee about one-third of the slow sand filters originally used to filter lake water have been given over to the removal of iron from ground water supplies obtained from wells near the lake. The water is pumped from the wells to elevated distributors, from which it trickles over many series of wooden gratings, during which process the iron becomes completely oxidized.

FIG. 3. LABORATORY FOR WATER HYGIENE, BERLIN-DAHLEM, GERMANY

A new plant at Wuhlheide obtains ground water from eighty driven wells. It had been in operation only five days at the time of this visit. The water from the wells is pumped to the upper part of a high building (Fig. 4) and sprayed through special nozzles over beds of coarse gravel. The water having been thoroughly aerated and the iron oxidized, it is passed through pressure filters

(Fig. 5). The plant had been in operation only a few days, but, from the experiments from which the plant was designed, it is expected that good results in iron removal will be obtained.

The Prussian authorities are very particular to protect the streams from pollution by sewage. This is especially necessary because of the small flow and the sluggish character of the streams. Berlin proper owns large irrigation fields to which the sewage is pumped; 43,000 acres in all are owned; 21,000 are in use. It is rumored that Berlin is giving up sewage irrigation. Berlin proper is not doing so. The suburbs have, however, found it necessary to adopt biological processes of purification because of the lack of suitable land for irrigation fields. The sewage from twelve districts in Berlin is pumped to various sewage fields. The fields at Gross Beeren are the largest in extent, and are typical of all the fields. The sewage passes through a pressure pipe line. An indicator tower shows the rate of flow. The heavy material is removed by open tanks. From the tanks it flows by gravity through open channels to the fields.

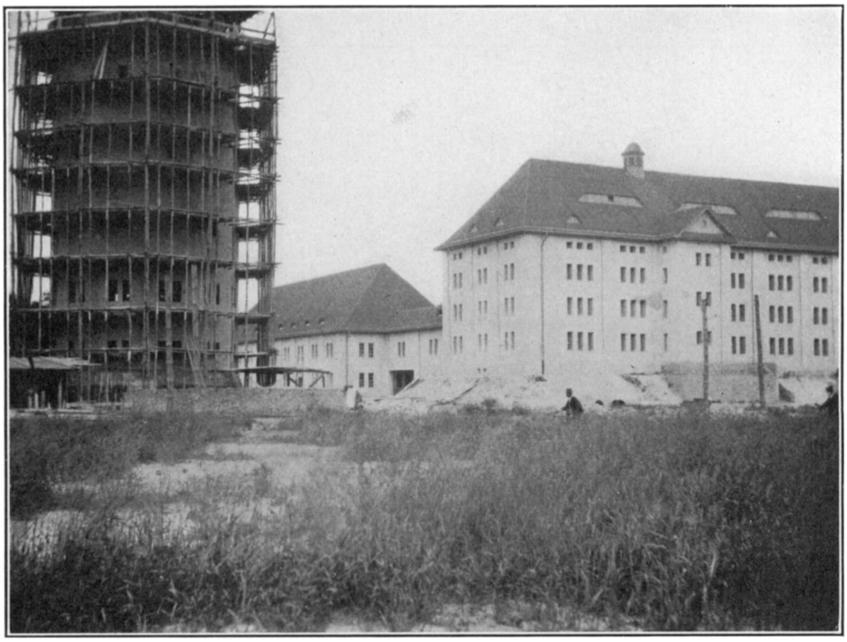

Fig. 4. Iron Removal Plant of Berlin Water Works, Wühlheide

The land in the fields is rented to the peasants, who are willing to pay twice as much for lands inside these irrigation fields as for land outside. On some of the fields several crops are harvested each year. The vegetables raised were especially noteworthy, most of the vegetables used in Berlin being obtained from the sewage farms. One other crop is especially noteworthy, Italian rye grass, which may be harvested six times during the season. It grows to the height of a meter a month.

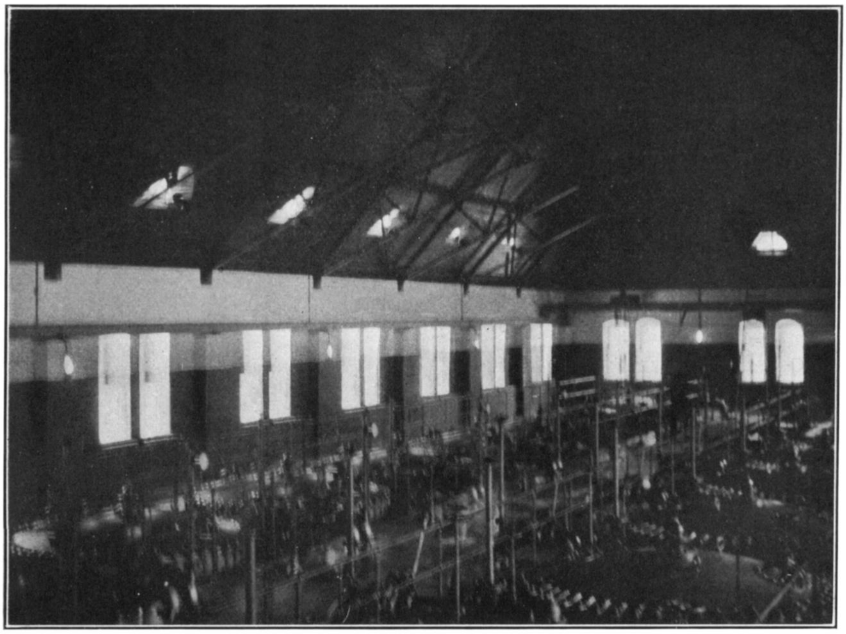

FIG. 5. PRESSURE FILTERS, IRON REMOVAL PLANT, BERLIN WATER WORKS, WÜHLHEIDE

Tanks or sprinkling filters are in use at Wilmersdorf, one of the larger suburbs, and in other parts of Greater Berlin.

Especial attention was called to the Reinsch screens[4] in use at Eberswalde. These are revolving screens having numerous holes about $\frac{1}{16}$ inch by $\frac{1}{2}$ inch. The screens are cleaned by revolving brushes. The sludge obtained is sold to the farmers who allow it to ripen for use as a fertilizer. Very complete purification is obtained at Eberswalde. The sewage, after screening, is passed into septic tanks and through sprinkling filters with a unique system of distribution (Fig. 6). The sewage passes to a trough along the side of the filter beds. From this trough it is syphoned to a travelling cylindrical distributor containing numerous buckets. When these buckets are filled the weight causes the traveler to move. A check at the end of the bed reverses the flow and the direction of the traveler.

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[4] *Engineering and Contracting*, 42, 273–6.

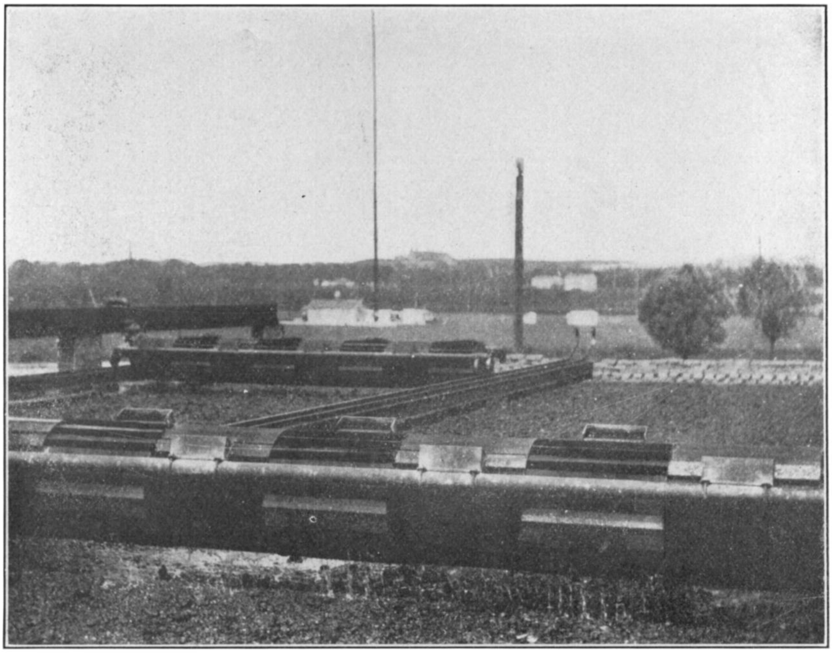

Fig. 6. Sewage Distributors Sprinkling Filters, Eberswalde, Germany

It then passes through contact beds and is finally discharged into a canal.

At Cöpenick, another Berlin suburb, the sewage is mixed with finely ground lignite or brown coal, and a small amount of alum to serve as a coagulant. A very complete mixing is obtained by means of perforated baffles (Fig. 7). The mixing is much more satisfactory than when the baffles were solid. The thoroughly mixed sewage and lignite pass to large sedimentation basins. Much of the suspended matter settles near the inlet. Very little baffling is needed, and an effluent satisfactory to the government authorities is obtained Three sedimentation basins are provided. While one is in use as a sedimentation basin, in the second the sludge is being dried, and in the third the dried sludge is being removed. The dried sludge is burned for fuel, alone in the furnaces under the low pressure boilers, and mixed with one to two parts of coal under the high pressure boilers, which supply power to the electric light plant of the city.

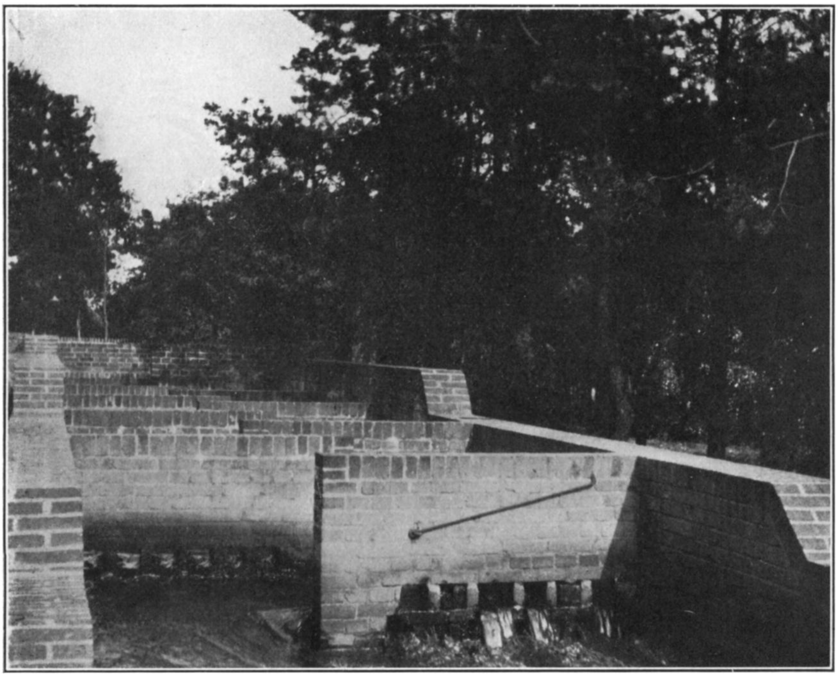

FIG. 7. PERFORATED BAFFLE, CÖPENICK, GERMANY

It is stated that more satisfactory drying of the sludge takes place when it is piled to a height of several feet, than when spread out in a thin sheet, probably due to the pressure exerted on the lower porous layers.

At Dresden the water supply is obtained from wells. Serious difficulties have been experienced because of the manganese content of the Dresden water supply. Service pipes become filled with a black precipitate, and the water cannot always be used for the laundry. Two manganese removal plants are in operation. One consists of gravity filters built in the original reservoir. The water passes through coarse sand on which manganese removing algae have been developed. These filters are washed by reversing the current, and are probably the nearest approach to the mechanical gravity filters in use in the United States. The second plant consists of pressure filters. One-half are filled with manganese permutit and half with gravel on which a manganese removing organism has been allowed to develop. Both processes are satisfactory, but owing to the economy of the sand and manganese removing organism this process seems to be better than the manganese permutit. A very satisfactory account of the experiments performed at Dresden is given by Tillmans.[5]

Reinsch screens have been recently adopted at Dresden for sewage treatment. The dry weather flow is taken care of by one screen. The storm water sometimes requires four to be put in operation. Without further treatment the sewage is allowed to flow into the Elbe. There is sufficient diluting water to render the sewage innocuous.[6]

No photographs could be obtained of a sewage disposal plant at Coethen, as the plant was visited during a heavy rain storm and photography was out of the question. This plant has been designed by Baumeister Benzel with Dr. Dunbar of the Hamburg Hygienic Laboratory as consultant. By settling ninety-two per cent of the suspended matter is removed, and the sludge is withdrawn before it has time to putrefy. In the bottom are sixteen transverse divisions, each sloping to a trough to which the sediment settles. When this sediment is to be removed, a sliding door separates the trough from the upper part of the tank. The opening of a gate on the side of the tank allows the greater part of the sludge to flow out, the balance is drawn out by means of a hoe. The gate is closed, the trough filled with water and the sliding door opened without any disturbance of the liquid above. The effluent from the tank passes to sprinkling filters which are well constructed with an outside concrete retaining wall of a special design. In the center is a specially designed piece of concrete so arranged that the underdrains can be flushed out with hose whenever desired. Green algae were growing in the effluent drains, showing a very satisfactory purification. Owing to the fact that the plant is new, and that it takes care of both sanitary sewage and storm water, and that comparatively few sanitary connections have been made, the plant should receive a more extended trial before the design is unreservedly recommended.

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[5] *Journal für Gasbeleuchtung und Wasser Versorgung*, 57, 713–24.

[6] Datesman, *Journal of the American Water Works Association*, Vol. 1, 365.

At Magdeburg the Puech-Chabal filters of the Magdeburg water system were visited. Magdeburg has the only large plant of this kind. The authorities are apparently satisfied with it for they are doubling its size. At Magdeburg they use not only the prefilters, but also the socalled rapid filters and final sand filters. It may be necessary to take such precautions with the water from the Elbe, but the installation is certainly very expensive and the cost of filtration must be high. A very good description of these filters is found in *Engineering*, 89, 117, 132, 164.

At Munich the sewage without any purification whatever is allowed to flow into the swift flowing Isar River. Sewage purification is unnecessary because the water below the city is not used for drinking purposes and is too cold for bathing. The engineer stated that within sixty miles all traces of sewage had disappeared. Owing to the outbreak of the war, Munich was the last German city visited.

The cities visited in Germany furnish a good series of illustrations of sewage disposal methods, from straight dilution up to the most thorough treatment.

Owing to the war the London water works were under an armed guard, and it would have been necessary to obtain special permission to visit the plant. Under those circumstances it seemed unwise to ask the authorities for the special favor.

An interesting plant visited in England was the water softening plant of the Woolcombers Ltd. at Bradford, where 50,000 gallons per day of water having a hardness equivalent to thirty grains per gallon were softened to zero by lime, soda and permutit. Permutit alone was not satisfactory and the combined soda ash, lime, permutit plant was installed. The water is first treated with lime and soda, passed through a settling tank, then over calcium permutit to remove the suspended matter and excess of alkalinity. A permutit filter gives the final product of zero hardness. The process is said by the chemist and superintendent to be very satisfactory. Two pounds of soap per grain per gallon per 1000 gallons is the saving made. This is a saving of 60 pounds per thousand gallons.

The largest and probably the only municipal permutit water softening plant is located at Hooten, near Liverpool. This plant was built to furnish a water guaranteed to have less than ten grains per gallon of hardness. The original water contains about thirty grains per gallon. Two-thirds of the water is reduced to a hardness of zero, and is then mixed with one-third its volume of the original water. Owing to lack of time, the plant was not visited, but, in an interview Mr. Bettle, the superintendent, stated that the process was satisfactory, and that, if it were necessary to enlarge the plant, the same process would be used.

An interesting feature in sewage purification, aëration, was observed at Manchester. The preliminary experiments have been described in the 1914 *Annual Report* of the Rivers Department of the Corporation of Manchester. This process in brief consists in blowing compressed air through sewage until what is known as activated sludge is developed. This sludge added to sewage and stirred by air has the property of purifying the sewage very rapidly. For example, with a tank containing 1300 cubic feet in which are 300 cubic feet of activated sludge, 1000 cubic feet of sewage can be treated every six hours, or 4000 cubic feet of sewage can be treated daily. This allows four hours for treatment, two hours for settling, emptying and filling. It is claimed that by this process a sewage effluent can be obtained which is in better condition than an effluent which has passed through Imhoff tanks and sprinkling filters. If the claims of the process are borne out by further experience, it is expected that considerable sums will be saved in the construction of sewage purification works. Professor Fowler, under whose direction the experiments have been carried out, has consented to serve as advisor for carrying on experiments in the laboratory of the Water Survey. Later his services would be available as consultant for the construction of plants on a larger scale.[7]

To show the stress under which water works men are working, it need only be stated that in one place six rifles were leaning against the wall of the office, and the superintendent stated that the three plants of his company were watched by armed guards night and day. The men in charge of the various plants visited were very cordial, and, even after war broke out, when many of the assistants had volunteered and extra work devolved on those left, most courteous attention was extended.

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[7] Ardern and Lockett, *Jour. Soc. Chem. Ind.* 33, 523–39.